CERTLABZ CERTIFICATION BOARD

Certified Quantum Engineering Professional (CQEP)

Ten Sample Questions

These ten questions are written at the difficulty of the live exam. Six carry a figure, a data table, a configuration or a code listing; four are plain scenario questions, as on the live paper. Every one is a scenario a working engineer would meet, and none of them appears in the live question bank.

The live exam is multistage adaptive: how you score on one stage selects the difficulty of the next, so no two candidates sit the same paper. It is a performance-based exam: each form can carry up to 5 to 12 performance-based questions alongside the multiple-choice questions, which means you build, sequence or complete something rather than only choosing from a list. Answers and full explanations follow each question here; the live exam does not disclose item-level answers.

Question 1 — Domain 2: Gates, Circuits and Measurement — CIRCUIT

Liam Anderson reviews a teammate's state-preparation routine. It is meant to leave two qubits in the Bell state (|00> + |11>)/√2. Trace the circuit and use the counts to decide what actually happened.

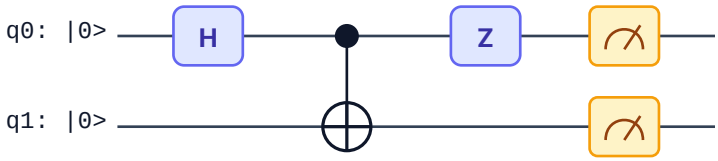


Figure 1.1 The routine as committed. Time runs left to right.

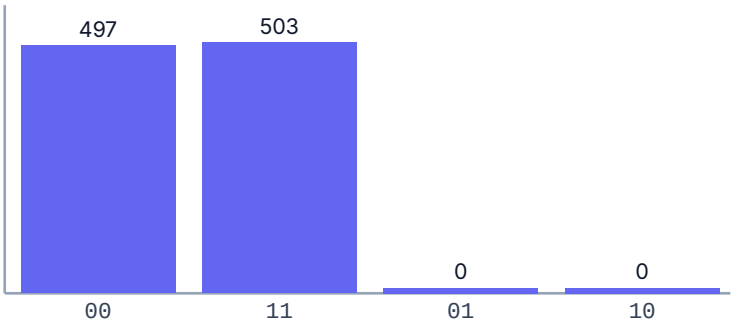


Figure 1.2 Counts from 1,000 shots on a noiseless simulator.

Which statement correctly explains the situation?

(A) The circuit is correct and the even split between 00 and 11 confirms the intended Bell state was prepared exactly.

(B) The Z gate destroys the entanglement, so the counts should have shown all four outcomes in roughly equal numbers.

(C) The circuit yields (|00> − |11>)/√2, a different Bell state; the counts cannot show it because Z-basis measurement is blind to phase.

(D) The Z gate flips qubit 0 after the CNOT, so the counts should have concentrated on the 01 and 10 outcomes instead.

Correct answer: C
H then CNOT gives (|00> + |11>)/√2. The Z gate multiplies the branch where q0 is 1 by −1, producing (|00> − |11>)/√2. Both states give 50/50 on 00 and 11 under the Born rule, so the counts look identical. Detecting the sign needs a basis change: apply CNOT then H before measuring, and the faulty circuit reads 10 every time while the correct one reads 00.

Question 2

Domain 4: Hardware, Noise and Error Correction

DATA

Ava Thompson must place a two-qubit subroutine on the device below. It needs one CNOT repeated 400 times between a single pair of physical qubits, and only directly connected pairs can host a CNOT without routing.

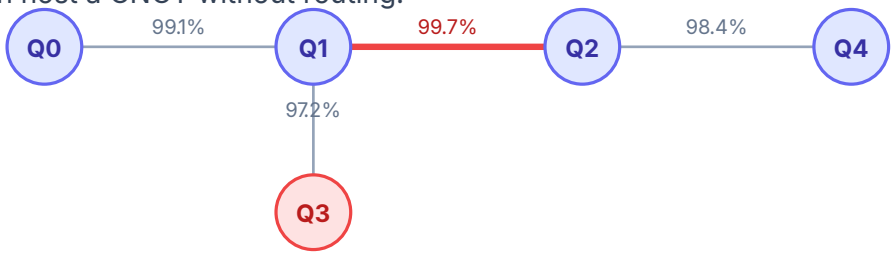


Figure 2.1 Coupling map with two-qubit gate fidelity on each edge. Q3 is flagged for high leakage.

Qubit	T1 (µs)	T2 (µs)	Readout error
Q0	118	84	1.9%
Q1	141	96	1.2%
Q2	133	91	1.4%
Q3	62	38	4.7%
Q4	109	77	2.6%

Table 2.1 Calibration snapshot taken the same morning.

Each CNOT takes 240 ns. Which placement is correct, and roughly what fraction of shots survive the 400 gates without a two-qubit gate error?

(A) Q1 and Q2, and about 30 percent of shots survive, because 0.997 raised to the 400th power is roughly 0.30.

B Q1 and Q2, and about 99.7 percent of shots survive, because the fidelity applies once to the whole sequence.

C Q0 and Q1, and about 70 percent of shots survive, because Q0 has the shortest readout time on the device.

D Q2 and Q4, and about 45 percent of shots survive, because Q4 is the furthest qubit from the leaky Q3.

Correct answer: A
The best edge is Q1-Q2 at 99.7 percent. Gate errors compound: 0.997^400 is about 0.30, so roughly 30 percent of shots complete all 400 gates cleanly. The sequence takes 96 µs, inside both qubits' T1 and T2, so coherence is not the limiting factor here. Option B forgets that fidelity compounds per gate; C and D choose worse edges.

Question 3 — Domain 6: Post-Quantum Security and Business Adoption — TIMELINE

Olivia Davis advises a hospital whose imaging records must stay confidential for 25 years. The migration to post-quantum key exchange is scoped at 7 years if it starts now, or 10 years if deferred. The risk committee uses a 15-year horizon for a cryptographically relevant quantum computer.

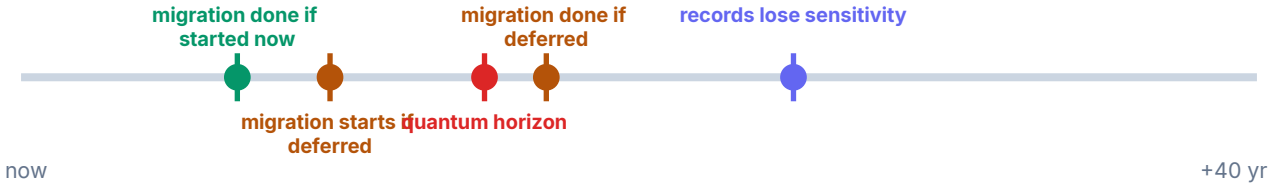


Figure 3.1 Both migration plans against the horizon, in years from today.

Which statement should she put in front of the board?

A Starting now is safe because the migration finishes at year 7, well before the horizon, so nothing recorded is exposed.

B Data sent today is already exposed either way; the network paths carrying imaging must move to hybrid key exchange first.

C Deferring is acceptable because the horizon is an estimate and the migration would still finish only two years late.

D Neither plan matters because AES-256 protects the records and only the signatures on them are at quantum risk.

Correct answer: B
Mosca's inequality compares shelf life plus migration time with the horizon: 25 + 7 = 32 and 25 + 10 = 35, both far beyond 15. Records transmitted before the migration completes can be captured now and decrypted later, so the imaging paths need hybrid post-quantum key exchange immediately, ahead of the general programme. AES protects the payload only if the key exchange that delivered the key survives.

Question 4 — Domain 5: Programming, Simulation and Hybrid Workflows — CODE

James Carter is asked why a variational job that ran in minutes on a simulator now takes most of a day on cloud hardware. The loop is below.

```
for step in range(2000):
    qc = build_ansatz(theta)          # rebuilt every step
    tqc = transpile(qc, backend)      # ~2 s
    job = backend.run(tqc, shots=2000) # queue ~30 s, run ~1 s
    e = expectation(job.result())
    theta = optimizer.step(e)
```

Listing 4.1 The optimisation loop as written.

Which change removes most of the wall-clock time?

A. Raise the shot count to 20,000 so each energy estimate is more accurate and the optimiser needs far fewer steps.

B. Move to a backend with many more qubits so the ansatz can be wider and the optimiser converges in far fewer iterations.

C. Replace the gradient optimiser with a random search so that no evaluation depends on the previous step and its result.

D. Transpile the parameterised circuit once, bind values each step, and run inside a session so the queue is paid once.

Correct answer: D

Each step pays about 33 seconds of queue and transpilation for one second of execution, so 2,000 steps take around 18 hours. Transpiling once and binding parameters removes the 2 seconds; a session or batched execution removes the 30-second queue. Neither more shots nor more qubits reduces the per-step overhead, and random search only multiplies the number of evaluations.

Question 5

Domain 1: Quantum Information Foundations

DATA

A three-qubit register is prepared in $(1/2)|000\rangle + (1/2)|011\rangle + (1/\sqrt{2})|110\rangle$ and measured 2,000 times on a noiseless simulator. Emma Wilson checks the counts against the state.

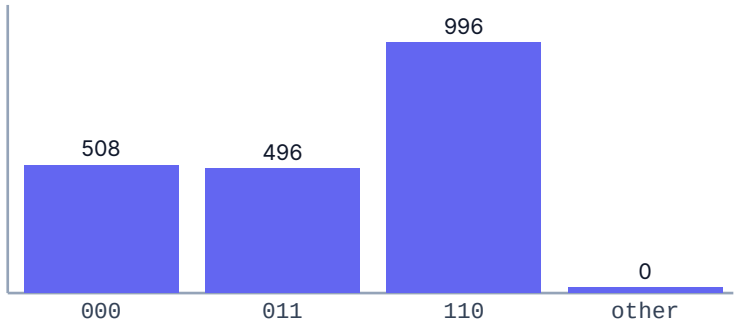


Figure 5.1 Counts from 2,000 shots.

Which conclusion is correct?

A. The counts match the state: 000 and 011 each carry probability 1/4 and 110 carries 1/2, so the first qubit reads 1 half the time.

B. The counts are wrong: three equal amplitudes should give three equal bars, so the simulator has a normalisation bug.

C The counts show 110 twice as often because its amplitude is twice as large, so the first qubit reads 1 two thirds of the time.

D The counts cannot be checked against the state because measuring three qubits at once destroys the relative amplitudes.

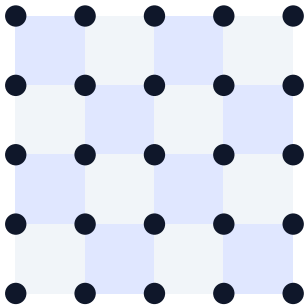
Correct answer: A
Probabilities are amplitude moduli squared: (1/2)^2 = 1/4 for 000 and 011, (1/√2)^2 = 1/2 for 110. Over 2,000 shots that predicts about 500, 500 and 1,000, which is what the histogram shows. Only 110 has a leading 1, so P(first qubit = 1) = 1/2. The amplitude 1/√2 is about 1.41 times 1/2, not twice, and probability scales with the square.

Question 6

Domain 4: Hardware, Noise and Error Correction

FIGURE

A vendor demonstrates a surface-code patch and reports the logical error per cycle at three code distances. The patch and the figures are below.



Filled dots are data qubits. Shaded plaquettes are Z stabilizers, plain ones X stabilizers. Distance d = 5.

Figure 6.1 A distance-5 surface-code patch: data qubits on the vertices, stabiliser plaquettes between them.

Code distance	Physical qubits in patch	Logical error per cycle
3	17	3.0 x 10^-3
5	49	1.4 x 10^-3
7	97	0.6 x 10^-3

Table 6.1 Reported results. Physical two-qubit error is about 3 x 10^-3.

What do these results establish?

A The device is fault tolerant, because a distance-7 patch already has a lower error than any single physical qubit.

B The device is above threshold, because 97 physical qubits deliver only one logical qubit and the error is still nonzero.

C The device is below threshold: logical error falls as distance grows, so adding qubits buys exponentially better logical qubits.

D The results are inconclusive, because a surface code needs distance 25 or more before any error suppression can be seen.

Correct answer: C
Error suppression with increasing distance is the defining below-threshold signature: roughly a factor of two per step from 3 to 5 to 7. It does not make the device fault tolerant yet; that needs many logical qubits, logical gates and magic-state factories. Suppression is visible at small distances precisely because the physical error is below the code threshold.

Question 7 Domain 3: Algorithms and Complexity

A product manager proposes using Grover's algorithm to search a customer database of ten million records for a fraud pattern, expecting a quadratic speed-up over the current scan. What is the correct engineering assessment?

A. The speed-up holds only for the oracle calls; loading ten million records into superposition costs at least as much as the scan.

B. The speed-up is real and the project should proceed, because Grover applies to any unstructured search over stored data.

C. The speed-up is exponential rather than quadratic once the database exceeds a million records, so it is even better.

D. The speed-up applies but only on trapped-ion hardware, because superconducting devices cannot hold ten million records.

Correct answer: A
Grover reduces the number of oracle queries from N to about √N. It says nothing about building the oracle or preparing the input state, and encoding N classical records generally costs time proportional to N. For stored data the loading step erases the gain, which is why database search is the textbook example of a misapplied speed-up.

Question 8 Domain 2: Gates, Circuits and Measurement

Two engineers disagree about a single-qubit state. One says $-|0\rangle$ is physically different from $|0\rangle$ because the sign is visible in the amplitude. The other says they are the same state. Who is right, and why?

A. The first: the minus sign flips every measurement outcome, so the two states give opposite results in any basis.

B. The first: the minus sign is a relative phase that changes interference, so an H gate would separate the two states.

C. The second: the sign is a global phase that cancels in every probability, so no measurement in any basis can detect it.

D. Neither: $-|0\rangle$ is not a valid state vector because amplitudes must be positive real numbers to be normalised.

Correct answer: C
A global phase multiplies the whole state and disappears from every probability $|\langle x|\psi\rangle|^2$. Only phases between components of a superposition, relative phases, are observable. Amplitudes may be negative or complex; normalisation constrains their moduli, not their signs.

Question 9

Domain 6: Post-Quantum Security and Business Adoption

A vendor proposes securing a bank's data-centre links with quantum key distribution and describes it as the complete answer to the quantum threat. Which assessment is accurate?

A. Accurate: QKD provides information-theoretic security for both key exchange and authentication over any existing network.

B. Partly accurate: QKD secures the links and only the bank's stored archives still need post-quantum algorithms.

C. Inaccurate: QKD needs dedicated links and a classical authenticated channel, and it provides no signatures, so PQC is still required.

D. Inaccurate: QKD is not yet commercially available, so the bank should wait for hardware before deciding on any migration.

Correct answer: C

QKD distributes keys between two fixed points over dedicated fibre or free-space links and still relies on a classically authenticated channel. It does not sign anything and cannot protect the internet at large, which is why national security guidance recommends post-quantum cryptography as the general solution and treats QKD as at most a niche complement.

Question 10

Domain 3: Algorithms and Complexity

A team runs a variational algorithm on a 50-qubit hardware-efficient ansatz and finds that every gradient component is effectively zero from the first iteration, whatever the starting point. What is happening, and what is the sound response?

A. The optimiser has converged immediately, so the team should record the result as the ground-state energy and stop.

B. A barren plateau: gradients vanish exponentially with width for such ansätze, so a structured or problem-informed ansatz is needed.

C. Hardware noise has zeroed the gradients, so raising the shot count by a factor of ten will restore a usable signal.

D. The parameters were initialised at zero, so shifting every angle by π/4 will move the circuit off the flat region.

Correct answer: B

Random hardware-efficient ansätze on many qubits concentrate on a landscape whose gradients shrink exponentially with width, the barren plateau. More shots cannot resolve a gradient that is exponentially small, and a constant shift lands on the same plateau. Problem-inspired ansätze, layer-wise training and smart initialisation are the known mitigations.

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